Chirurgical Society: with the author

ON THE COMPARATIVE VALUE

OF

CERTAIN SALTS

FOR RENDERING

FABRICS NON-INFLAMMABLE:

BEING THE

SUBSTANCE OF A PAPER READ BEFORE THE

British Association,

AT THE MEETING IN ABERDEEN, SEPTEMBER 15, 1859.

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MDCCCLIX.

What friend is like the might of fire,
When man can watch and wield the ire?
Whate'er we shape or work, we owe
Still to that heaven-descended glow.
But dread the heaven-descended glow,
When from the chain its wild wings go;
When, where it listeth, wide and wild,
Sweeps forth free Nature's free-born child!

From BULWER'S *Translation of* SCHILLER'S "LAY OF THE BELL."

INTRODUCTORY REMARKS.

During the last winter some of the leading journals of London contained letters commenting upon the number of accidents which were almost daily happening, from the fact of light dresses and curtains catching fire, and earnestly calling for expedients to prevent occurrences which had but too often assumed a most dangerous character. Her Majesty, in like manner, desired the Master of the Mint to report to her on this important subject, and Professor Graham was kind enough to intrust the investigation to the authors of the present pamphlet. A lengthened series of experiments led up to results, which were subsequently communicated in a paper read before the British Association at the meeting recently held at Aberdeen. In offering them anew in print, we are guided by the belief that the interest evinced by the public in the letters above referred to, has in no way abated, and that manufacturers, on perusing the succeeding pages, may feel induced to carry out the plans therein advocated. The number of salts over which our investigations have extended will secure the manufacturer

against adopting to-day a process likely to be superseded on the morrow, and unexceptionable certificates appended to this dissertation will demonstrate that the processes recommended in no wise injure either the colour or the strength of the fabrics operated upon.

All endeavours permanently to fix in cotton or linen anti-flammable expedients have hitherto proved unavailing, inasmuch as substances thus prepared are found to suffer materially; and the large quantity of oxides required for this purpose leave but little hope that the result will ever be obtained, save at the expense of the fabrics. The processes recommended need not, however, be confined to these latter; for, among other inflammable goods, paper may be instanced as one deserving in this particular great consideration.

Every attempt to impart to organic substances the property of resisting wholly the influence of fire must ever remain unsuccessful, on account of its ignoring an inherent quality of organic nature, viz., liability to decomposition by heat. But as soon as this decomposition remains confined to that point of a substance, where it is in immediate contact with the flame, so that it is impossible for the latter to spread, as soon as the substance itself is *non-inflammable,* all danger of a conflagration ceases. The daily reports in newspapers obviate the necessity of particularizing instances of those painful occurrences, which will, we trust, hence-

forth be forestalled. The candles of a Christmas-tree, the chandeliers in a ball room, the stage lamps, and household fires lighted for the purpose of warming the dressing-room of an invalid, or to cook a meal, have frequently called and continue to call for sacrifices like that recorded by Casimir Delavigne in one of his most touching ballads. One great calamity, however, we would recall to the reader's recollection. When Prince Schwarzenberg, the Austrian ambassador in Paris in the year 1810, was entertaining the first Emperor of France in his residence at a brilliant ball, a curtain caught fire from a chandelier, and in a few seconds the whole of the curtains, blinds, paper-hangings, and the garlands of artificial flowers which covered the walls—nay, the very walls themselves, which were partly built of wood—became one mass of flames. The dresses of the ladies began to blaze, and a general panic ensuing increased the danger and confusion. The emperor and empress could scarcely reach their carriage. A number of thieves, finding their way into the crowd, carried off the jewels, which strewed the floor, and the emperor's sister, the Princess Pauline, and the Countess of Schwarzenberg, the lady of the house herself, lost their lives through the disaster. If a monster accident like this has not availed yet, to induce the adoption of some of those preventive expedients hitherto proposed, it is but too obvious that a new investigation into the subject at large has become deeply urgent.

Although we have deemed it both expedient and

consistent to secure ourselves by taking out patents for the processes which we have found most available, manufacturers who shall feel disposed to adopt the latter may reckon upon meeting with liberal co-operation on our part.

Chemical Laboratory,
Bury Court, St. Mary Axe.
October, 1859.

ON THE COMPARATIVE VALUE OF CERTAIN SALTS FOR RENDERING FIBROUS SUBSTANCES NON-INFLAMMABLE.

A Communication read before The British Association for the Advancement of Science, *at* Aberdeen, *the* 15*th* September, 1859, *by* Fred. Versmann, F.C.S., *and* A. Oppenheim, Ph.D., A.C.S.

The difference between the chemical constitution of the animal and the vegetable fibre, the first containing about eighteen per cent. of nitrogen, whereas the latter consists exclusively of carbon, hydrogen, and oxygen, involves one of the greatest practical importance. The animal fibre, although subject to the destructive influence of heat, chars when in contact with a flame, but is not itself inflammable, because the gaseous products of its decomposition contain an amount of carbonate of ammonia sufficient to rarefy the inflammable hydro-carbons, so as to prevent them from burning. The vegetable fibre, however, if decomposed by heat, evolves gaseous hydro-carbons, mixed with oxide of carbon and little carbonic acid only, and communicates ignition, by burning with a flame.

Wherever it has been possible to dispense with the vegetable fibre in arts and manufactures, it has been substituted by less dangerous materials—wood being frequently replaced by iron, stone, or brick, and paper by parchment.

But the use of cotton and linen is ever on the increase, and will most likely never give place to more

solid substances. So great a number of conflagrations, and so considerable a loss of life originates yearly from the use of these inflammable substances, that we feel justified in attempting to direct the attention of this honourable Association to the following questions:—

What means may be applied for the rendering of these substances non-inflammable? What is the comparative value of these means? and why have none of the means hitherto recommended been introduced into public use?

Nitrogen being, as it were, the safeguard, protecting the animal fibre against fire, the first idea offering must be to introduce nitrogen into the vegetable fibre, in the shape of a soluble animal substance, such as glue or albumen. But these do not contain more nitrogen than hair or wool, or the animal substances from which glue is made, and it is easily to be anticipated that a very considerable quantity would be required to render the vegetable fibre non-inflammable, by which its pliability would be lost. Experiments made by us with that view, demonstrated that neither albumen, nor the most concentrated solution of isinglass, can produce that effect.

In order to learn, however, whether eighteen per cent. of nitrogen were really required to protect a thin vegetable fibre, we applied to a piece of fine muslin a solution of the organic substance, richer in nitrogen than any other—viz., urea. By introducing not less than 28 parts of urea into 100 parts of muslin, we protected the latter from burning with a flame. 28 parts of urea correspond to 13 parts of nitrogen, or the muslin, when rendered non-inflammable, contained 10·2 per cent. of nitrogen. Although this quantity is

smaller than might have been expected, still, for all practical purposes, we must look for an expedient amongst the inorganic salts, on account of their comparative cheapness, and all expedients hitherto proposed pertain to this class of substances.

In collecting the information on the subject, we find that, as early as 1735, a patent "for preventing combustible substances from flaming," was granted to one Obadiah Wild, who applied a mixture of alum, borax, and vitriol, either in solution or by mixing it with the pulp before it was made into paper.

This is most likely the process to which De Hemptine, a Belgian chemist, refers, in an essay, which appears to be the first extensive investigation of the subject in question, and which was published in the "Annales de l'Industrie," in 1821. He observes, that "the English use a kind of non-inflammable paper in the manufacture of cartridges for their navy."

The attention of many chemists of that period was apparently directed towards this subject, for De Hemptine mentions three compositions, proposed with the same view in other countries—viz., silicate of potash, by Brognatelli; sulphate of iron, by Hermbstaedt; and a substance of unknown composition by Delisle.

De Hemptine mentions a great number of substances proposed by himself and others, for rendering canvas and wood non-inflammable, although he himself denies that they are applicable to wood, without offering, however, any reason. He does not sufficiently sift these different expedients, and we find amongst them a number of salts quite useless for the purpose.

In the same year, a paper by Gay-Lussac, on the same subject, appeared in the "Annales de Chemie et Physique," tome 18, succeeded by a paper by Prater, in the "Phil. Transactions, 1839," on the use of the carbonates of potash and soda; a recommendation of Water-glass, by Fuchs at Munich; a notice on the use of a precipitate of sulphate of lime in the "Mittheilungen des Gewerbe Vereins für Hannover, 1841;" a paper by Dr. R. A. Smith, in the "Phil. Magazine," Ser. III., vol. 34; a number of notices of less import; and a large number of patents taken out for different mixtures in different years.

Gay-Lussac's dissertation on the subject is the only one which discusses the respective amount of different salts required for rendering a certain fabric non-inflammable.

He took solutions containing 25 grammes of anhydrous salt in always 250 cub. centimètres, for two series of experiments, with pieces of linen weighing three grammes each.

In the first series he introduced into the pieces of linen always three c. c. of the solution, or ten per cent. by weight of the anhydrous salt. Finding no salt to answer in this proportion, he made a second series of experiments, with double the quantity of salts in solution. He then found that linen may be rendered non-inflammable by taking up twenty per cent. of either of the following salts: viz.—

Chloride of ammonium, sulphate, phosphate, borate of ammonia, and borax, or by mixtures of any two of these salts. He likewise tried solutions of the tartrates of potash and soda, and of chloride of sodium, but without obtaining a favourable result.

Now, the small number of salts tested by Gay-Lussac, as well as the limit whereby he confines his experiments to two proportions only, prevents him from forming conclusions sufficiently general respecting the action of all salts suitable for the purpose. It likewise appears that he confined his experiments to the laboratory, and he was therefore unable to foresee the difficulties arising in the practical application of some of the salts.

Reserving some remarks on other investigations of later chemists, till we enter more at large upon the salts recommended by them, we proceed to describe the method by which we compared the value of forty different salts soluble in water. The experiments include the salts hitherto proposed; certain others, the application of which we were the first to try; others, again, worth investigating on account of their chemical analogies only.

Instead of comparing the quantities of different salts which must be taken up by a certain fabric, we tried to simplify the investigation by determining how strong a solution of different salts is required for our purpose. We thus found that the differences which various salts exhibit in this particular, are more marked than the differences in the increase of weight of fabrics immersed in various solutions, but we also found that both these differences were constant, provided we took care to remove the excess of liquid by squeezing, but without twisting, the muslin, till no drop of the liquid remained clinging to the fabric.

The muslin we used was free from starch and other stiffening agents; twelve inches square weighed 33·4 grains; the degree of non-inflammability was such

that the muslin was destroyed only in that part which was in immediate contact with the flame.

The failure to which this method is liable does not exceed two per cent.; and, although far from being entitled to claim absolute exactitude, it is sufficient for practical purposes, and for the explanation of the action of various salts.

Those salts which proved to be preferable on account of the small amount required, or by reason of their properties, were afterwards tested on a large scale, either in the finishing works of muslin manufacturers, or in laundries. The processes resorted to by finishers and by laundresses differ principally in this: that in the manufacturing process the muslin is finished without the application of heat, whereas in laundries the ironing with hot irons cannot be dispensed with.

We may here premise, that this circumstance explains, why none of the salts hitherto recommended have found favour with the public, none of them allowing the iron to pass smoothly over the fabric, and some even destroying it under the influence of the heat of the iron.

Before proceeding with our observations, we feel bound to express our acknowledgments for the kind and truly liberal assistance which we received from W. Crum, Esq., of Thornliebank, Glasgow, and from Alexander Cochran, Esq., of the Kirkton Bleaching Works, Glasgow, as well as for the favour which enabled us to make a large number of experiments in Her Majesty's Laundry at Richmond.

The Chlorides of Potassium and of Sodium proving to be decidedly ineffective, even when applied in concentrated solutions (although De Hemptine repeats an

assertion of M. Hassenfratz to the contrary), *the carbonates of potash and soda* must be considered to be the cheapest salts hitherto recommended. They have been proposed by Horatio Prater ("Phil. Mag. 1839," vol. 14), and by B. Cook ("London Journal of Arts and Manufactures," vol. 5, Ser. 1).

Solutions containing only ten per cent. of anhydrous carbonates are quite effective. Both salts, however, cannot be practically applied, because the carbonate of potash is deliquescent, and the carbonate of soda is highly efflorescent, and thereby converted into dust, which does not adhere, and injures the transparency of the fabric. If we try to explain the action of these salts, three reasons offer: The reason given by Prater, who attributes their protecting power to the carbonic acid, which, according to Gay-Lussac, and Thenard, leaves the alkali at red heat under the influence of water gas. This explanation is proved to be correct by the inflated appearance of the cinder remaining. Another reason is contended for by De Hemptine, who thinks that it is the water gas as well which prevents ignition, by leaving the crystals at high temperature. Against this theory we must quote other salts, which, like the phosphate of soda, are almost useless, although they contain a much larger amount of water. A third theory, which we beg to suggest is, that the carbonate of soda acts by firmly enveloping the fabric in a fused state, and that the carbonate of potash, which does not become liquid at a temperature when muslin would begin to burn, surrounds the fibre in its solid state, so as to prevent the contact with the air. This theory is supported by the fact that other substances, which do not give off gases, and

are fusible at a high temperature only, can protect the fibre.

The Hydrate of Soda, for instance, protects in an eight per cent. solution, and the cinder remaining does not appear to be fused.

The Bicarbonate of Soda acts better than the carbonate, inasmuch as it contains another equivalent of carbonic acid, a six per cent. solution being sufficient. But the second equivalent is given off so very readily, that a piece of muslin prepared with this salt, and brought in contact with a flame for a second or two, caught fire after all; and this inconvenience cannot be removed by applying a more concentrated solution.

Of *Borax,* one of the oldest expedients recommended, a twenty-five per cent. solution, is the weakest that can be applied; this corresponds to 13·2 per cent. of anhydrous salt. A piece of muslin prepared with borax, and then ironed, was perfectly rotten, whereby the application of this salt becomes at once impracticable. The alcalinity of the salt was first assumed as the cause of this action; but it was found that borate of ammonia acts in a similar way, even when applied in very small proportions. It then became evident that the boracic acid must have the peculiar corrosive property, a fact which was fully proved by using this substance by itself. Boracic acid does not protect the fabric, not even a concentrated solution; but the fabric, when ironed, becomes entirely rotten.

Of *Phosphate of Soda,* a solution containing thirty-two per cent. of anhydrous salt, or eighty per cent. of crystals, is required; so that the muslin gets perfectly hardened by the large quantity of salt.

Sulphate of Soda was found not to act as a protector,

although a hot concentrated solution, containing seventy-two per cent. of crystals, was used.

But *Bisulphate* was found to act in a twenty per cent. solution, and

Sulphite of Soda, in a twenty-five per cent. solution. Both these salts are, of course, injurious to the fabric.

Silicate of Soda, or Water-glass, was recommended as an anti-flammable by Fuchs, on occasion of the conflagration of the Theatre Royal, at Munich, and by many chemists since. A report on the applicability of this salt, by a commission of the Society of Arts of Berlin, in 1841, however, is exceedingly unfavourable. (Verhandlungen des Gewerbe Vereins, vol. 49.) They think it unfit for the protection of buildings, because a coating of it cracks and scales off, and does not enter into the fibre of the wood. It may be considered more useful for paper and certain fabrics, although it gives them an unpleasant japanned appearance if applied in a concentrated solution, and it makes them very rough, if more diluted.

The Water-glass we used in our experiments contained 37·7 per cent. of sesquisilicate of soda, and 6·3 per cent. of caustic soda. We had to mix forty parts of this viscid liquid with sixty parts of water, to obtain a solution of minimum strength, which contained 15·5 per cent. of silicate, and 2·5 per cent of caustic soda.

Stannate of Soda gave a satisfactory result with a solution of twenty per cent. of crystals, or 15·9 per cent. of anhydrous salt; but it cannot be applied, because it is strongly alkaline and hygrocopic.

As white lead may be replaced, in an economical point of view, by tungstate of lead, the *Tungstate of*

Soda ranges among the salts which are manufactured on a large scale and at a cheap rate. This salt, although it contains only ten per cent. of water, and does not evolve gaseous products at high temperatures, and although it is not easily fused, acts as a most excellent expedient. A solution containing twenty per cent. renders the muslin perfectly non-inflammable. It acts, apparently, by firmly enveloping the fibre, and thereby excluding the contact with the air. It is very smooth, and of a fatty appearance, like talcum; and this property facilitates the ironing process, which all other salts resist. We shall recur to its valuable properties.

The Chlorides of Potassium and Sodium proving to be useless, the corresponding *Iodides and Bromides* were not tested.

Cyanide of Potassium is a good protector in a ten per cent. solution already. It acts by evolving ammonia and carbonic acid at a high temperature, so that the cinder remaining is singularly inflated; but the high price and the poisonous character of the salt exclude it from practical use.

Passing from the fixed alkalies to certain salts of ammonia, it must be observed, that

The Carbonate of Ammonia cannot be applied, because it is but slightly soluble, and so volatile, that it evaporates during the drying of the prepared fabric.

The Oxalate of Ammonia aids ignition instead of preventing it; and as this substance, containing only so small an amount of carbon, has this effect, we did not examine any other organic salts.

The Tartrate of Potash and Soda, were found already by Gay-Lussac rather to favour the combustibility.

Biborate of Ammonia is effective in a five per cent. solution, but if not carefully prepared, it contains a larger per centage of boracic acid (four equivalents) and then a larger proportion of the salt is required. Its pernicious influence has already been mentioned; a solution containing only one per cent. of biborate of ammonia was found to destroy the fabric when ironed.

No salt has been more frequently recommended than *Phosphate of Ammonia,* by De Hemptine, Gay-Lussac, and other chemists. A ten per cent. solution is sufficient; but it offers the same resistance to the iron as other salts, and is not a cheap article. Mr. Maugham took out a patent, in 1856, for this salt mixed with starch. Mr. Cochran found, however, that if a mixture of salts with a thick paste of starch, like that used by manufacturers, is applied to fabrics, the salts are so unequally divided in the fabrics, that parts of the latter remain inflammable. If a thin paste, like that used by laundresses, is mixed with the salt, the proportion required of the latter is too large. The same remarks apply to the double salt of

Phosphates of Ammonia and Soda, which acts in a fifteen per cent. solution.

We now beg to direct the attention of the meeting to a salt which, although mentioned by Gay-Lussac as efficacious, has not hitherto been sufficiently held in value. We mean the

Sulphate of Ammonia, the cheapest salt of ammonia, because the ammonia obtained in gasworks is generally converted into the sulphate, and then frequently used as a manure. A solution containing seven per cent. of the crystals, or 6·2 per cent. of anhydrous salt, is a perfect anti-flammable. In 1839, the Bavarian em-

bassy at Paris caused M. Chevalier to make experiments before them with a mixture of borax and sulphate of ammonia, as recommended by Chevalier, in preference to the sulphate alone (Bair. Kunst und Gewerbe Blatt, 1839). He thought the sulphate would lose part of its ammonia, and thereby give rise to the action of sulphuric acid upon the fabric. This opinion seems to be confirmed by the fact that a solution of sulphate of ammonia gives off ammonia, as observed by Dr. R. A. Smith in his paper on substances which prevent fabrics from flaring ; but on the other hand, this may be easily counteracted by adding a little carbonate of ammonia, and, besides, the solid salt remains perfectly undecomposed. We now have kept for six months whole pieces of muslin prepared in various ways with this salt, some having been even ironed ; but we cannot find that the texture was in the least degree weakened. Chevalier's mixture, on the contrary, became injurious to the fabric, not only at temperatures above 212°, but even at summer heat ; and this can easily be explained, because he actually did not apply sulphate of ammonia and borax, but biborate of ammonia and sulphate of soda.

Another drawback of Chevalier's mixture is the roughness, which it gives to the fabric, and which could only be overcome by calendering the pieces, while sulphate of ammonia by itself has not this effect.

The use of this salt must therefore be strongly recommended, and we shall state at the termination of this review, how it is to be applied.

The Sulphite of Ammonia acts in a solution containing ten per cent. It is deliquescent.

The Chloride of Ammonium is effective only in very concentrated solutions, containing at least twenty-five per cent., whereas of the

Iodide and Bromide of Ammonium a five per cent. solution only is required. But the action of the chloride resembles that of the bicarbonate of soda, in as far as it volatilizes before the fabric takes fire; and so large a quantity is therefore required, that it renders the muslin stiff and injures its appearance.

The iodide and bromide of ammonium are of course salts too expensive to allow of their application.

Gay-Lussac recommended *a mixture of phosphate of ammonia with chloride of ammonium,* and Messrs. Thouret and Schussel, who obtained a patent for this mixture in 1857, mix three parts of sal ammonia and two parts of phosphate. It is cheaper than phosphate alone, although more expensive than the sulphate, but it resists the ironing as much as other salts, and offers no particular advantage.

Some of the salts of the earthy and metallic oxides having been recommended, we conclude by stating their comparative value.

Chloride of Barium protects as a fifty per cent. solution only.

Chloride of Calcium is efficacious in a solution containing ten per cent. of the dry salt, or 19·7 per cent. of crystals; but any application is excluded by the deliquescence of the salt.

Biphosphate of Lime has likewise been proposed by Domillard and Mary (Bairisches Kunst and Gewerbe Blatt, 1823). But it destroys entirely the fabric.

Of Sulphate of Magnesia fifty per cent. are required.

The *Tersulphate of Alumina* acts in a solution containing fifteen per cent. of the crystals or 7·7 per cent. of anhydrous salt, but here again the acid reaction makes the application impossible.

Alum has often been proposed, first by Obadiah Wilde (1735), by De Breza (1838), and others. De Breza took out a patent for the use of alum, mixed with boracic acid, sulphate of ammonia, and animal glue.

Of *Potash Alum* a thirty-three per cent. solution, and

Of *Ammonia Alum* a twenty-five per cent. solution is required, but both of them injure the appearance as well as the strength of fabrics. Of

Sulphate of Iron fifty-three per cent. is required, equal to 28·8 per cent. anhydrous salt. This salt has been used by Payne to protect the wood of several public buildings in London. (Mech. Mag. vol. 49.) Of

Sulphate of Copper a solution containing eighteen per cent. is efficient. The muslin prepared with it, gives off vapours of sulphuric acid, and the cinder remaining consists of red protoxide of copper. The properties of the salt interfere with its application.

Sulphate of Zinc is efficacious in a solution containing twenty per cent. of the crystals, although Gay-Lussac was of opinion that it would not suppress the flame. The salt is poisonous.

Chloride of Zinc, the subject of a patent of Sir W. Burnett, acts in a solution of eight per cent. of the crystals or 5·8 per cent. of anhydrous salt. The great tendency to attract moisture makes this salt quite unfit for more delicate fabrics; it may, however, be used for rendering oil paint non-inflammable, as communicated in the Report of the commission of the Society of Arts at Berlin, 1841.

Chloride of Tin is efficacious in a solution of five per cent. of the crystals; it is, however, too acid and deliquescent. Equally efficacious is the *double salt of protochloride of tin and chloride of ammonium*, acting in a

five per cent. solution. This salt, although colourless by itself, soon becomes yellow by the action of the air, which interferes with the introduction into delicate fabrics.

Pinksalt is very efficacious; a solution of seven per cent. being sufficient. But fabrics prepared with it are destroyed at a temperature of 212° Fahr., even with a perfectly neutral solution. The four salts last mentioned owe their preserving property chiefly to the fact, that heavy vapours absorbing a great deal of heat are evolved by them.

With regard to the other salts, we beg to draw the following conclusions:—

Every inorganic salt, if applied in solution to fabrics, diminishes their inflammability by absorbing heat and excluding the free access of the air. Even those salts, which, like saltpetre, give off oxygen and assist ignition, prevent fibrous substances from flaming, and even those salts, which, like chloride of sodium, proved not to protect the fibre, would most likely do so, if solutions concentrated enough could be obtained. More active than other salts are those, which are easily fusible, such as borax, or partially or entirely volatile, such as certain ammoniacal salts or those which, owing to their peculiar physical constitution, prevent the access of the air, such as the tungstate of soda. Of all the salts experimented upon, only four appear to be applicable for light fabrics.

These salts are the

1. *Phosphate of Ammonia.*
2. *The mixture of Phosphate of Ammonia and Chloride of Ammonium.*
3. *Sulphate of Ammonia.*
4. *Tungstate of Soda.*

The Sulphate of Ammonia is by far the cheapest and the most efficacious salt, and it was therefore tried on a large scale. Whole pieces of muslin (8 to 16 yards long) were finished, and then dipped into a solution containing 10 per cent. of the salt, and dried in the hydro-extractor. This was done with printed muslins, as with white ones, and none of the colour gave way, with the sole exception of madder purple, which became pale. But even this change might be avoided, if care be taken not to expose the piece while wet to a higher than ordinary temperature. Most of these experiments were made at the works of Mr. Crum and of Mr. Cochrane. The pieces had a good finish, and some of them were afterwards submitted to Her Majesty for inspection, who was pleased to express her satisfaction.

Mr. Crum, who prepared some dresses with phosphate and some with sulphate of ammonia, arrives at the result, that, with the phosphate, the finish is chalky and not transparent enough, whereas the finish with the sulphate is successful.

Other pieces, prepared with the sulphate, were exhibited in the Exhibition of Inventions of the Society of Arts, and at the Conversazione of the Pharmaceutical Society, in July last. If we repeat our observation, that during the space of six months, none of the fabrics prepared with sulphate of ammonia have changed either in colour or in texture, we consider it to be an established fact, that the sulphate of ammonia may be most advantageously applied in the finishing of muslins and similar highly inflammable fabrics.

We felt, however, the necessity of inquiring further

into the effect which ironing would have upon fabrics thus prepared. For all the above-mentioned salts, being soluble in water, require to be renewed after the prepared fabrics have been washed.

Now, the sulphate of ammonia does not interfere with the ironing so much as other salts do, because a comparatively small proportion is required; but still, the difficulty is unpleasant, and sometimes a prepared piece, after being ironed, showed brown spots like iron-moulds. On covering the iron with plates of zinc or brass, these spots did not appear; but the difficulty still existed, and a white precipitate covering the plate, showed evidently that it is the volatile nature of the salt which interferes with the process. An attempt to counteract this action of the salt, by adding wax and similar substances to the starch, remained also without any result.

ı or all laundry purposes, therefore, the TUNGSTATE OF SODA only can be recommended. This salt offers only one difficulty, viz., the formation of a bitungstate of little solubility, which crytallizes from the solution. To obtain a constant solution, this inconvenience must be surmounted; and it was found that not only phosphoric acid, in very small proportion, keeps the solution in its original state, but that a small percentage of phosphate of soda has the same effect.

The best way of preparing a solution of minimum strength is as follows:—A concentrated neutral solution of tungstate of soda is diluted with water to 28° Twaddle, and then mixed with 3 per cent. of phosphate of soda. This solution was found to keep and to answer well; it has been introduced into Her Majesty's laundry, where it is constantly being used.

The effects of the soluble salts having been thus compared, a few remarks are necessary respecting the means which may be adopted permanently to fix anti-flammable expedients, so that the substances prepared may be wetted without losing the property of being non-inflammable. This aim has been kept in view by a writer in the "Mittheilungen des Gewerbe Vereins für Hannover 1843," who tried to fix sulphate of lime in the fibrous fabric without success, and also by Mr. Morin, who tried to fix oxide of zinc by glue and by tannic acid, but without success. (Journal für praktische Chemie, vol. 24, page 281.) We tried equally unsuccessfully to fix *sulphate of baryta, phosphate of alumina,* and some of the *silicates of alkaline earths and of earths,* by precipitating them by double decomposition in the fibre; they all, however, wash out, and none of them acts as a perfect anti-flammable.

Relying upon the property of alumina as a mordant, we tried the combination of *oxide of zinc and alumina,* obtained by mixing solutions of oxide of zinc in ammonia and of alumina in caustic soda; but, although this precipitate protects the fibre, it does not adhere to it when washed.

The Oxychloride of Antimony, obtained by precipitation from an acid solution of chloride of antimony by water mixed with only a little ammonia, is a good anti-flammable, and it withstands the action of water, but not that of soap and soda. We did not find that the solution of this and other salts in muriatic acid injured the texture of the fabric, as long as this was dried at an ordinary temperature.

The Borate and Phosphate of Protoxide of Tin act effectually, if precipitated in the fibre from concentrated

solutions of these salts in muriatic acid by ammonia; they withstand the influence of washing, but give a yellow tinge to the fabrics.

The same remarks apply to *arseniate of tin*. *The stannates of lime and zinc* protect the fabric, but do not withstand the action of soap or soda.

The Oxides of Tin give a favourable result, in as much as they really can be permanently fixed; the yellow tinge, however, which they impart to the fabrics will always confine their application to coarse substances, such as canvas, sail cloth, or ropes. The binoxide does not act so well as the protoxide, it may be, because it cannot be applied in a sufficiently strong state, the bichloride of tin being too acid, at least when containing nitric acid, and the stannate of soda not yielding the amount of binoxide required; for a large quantity of oxide of tin is necessary. The best way to prepare sail cloth permanently non-inflammable is as follows:—The canvas is first soaked for two days in a solution of protochloride of tin containing two parts of crystallized salt in one part of water, and afterwards left for one day in a concentrated solution of either stannate of soda or carbonate of soda. On making use of the latter salt, we sometimes observed the formation of anhydrous protoxide of tin; and we found this always to be the case when solutions of protochloride of tin and carbonate of soda, quite concentrated, although cold, were mixed, so that the soda was in excess. The formation of the black anhydrous protoxide sometimes occupied twelve hours' time. It could be converted into the ordinary hydrate, by boiling it with protochloride of tin, and its formation could be prevented by agitating the canvas in the solution of soda.

The canvas thus prepared must be dried and then washed, to remove the excess of precipitate. Salt-water does not remove the tin from the canvas.

A few yards of sail-cloth thus prepared have been exhibited in the Society of Arts exhibition of inventions.

A piece about 40 yards in length has been prepared by order of the Storekeeper General of the Royal Navy; but it was found to have lost in strength, and increased in weight too much, to allow of its application.

These experiments, however, being the first successful attempts permanently to fix some anti-flammable agents, may have some interest, although they leave but little hope that the result of *fixing* anti-flammable expedients will ever be obtained without injuring the fabrics.

In concluding our investigation, we trust that we may have succeeded, as far as possible, in answering the questions raised by us in the beginning of this paper.

By determining the comparative value, and ascertaining the difficulties which have prevented, till now, the general use, of protecting agents, we were led to exclude a number of salts hitherto proposed, and to advocate the adoption of SULPHATE OF AMMONIA, and of TUNGSTATE OF SODA, in manufactories of light fabrics, and in laundries.

We hope, therefore, that the general introduction of these salts will soon greatly reduce danger and loss of life through fire.

TABLE

Showing the smallest percentage of Salts required in Solution, for rendering Muslin Non-Inflammable; A, of Crystallized; B, of Anhydrous Salts. Twelve square inches of the Muslin employed weighed 33·4 grains.

Name of Salts.	Formula of Salts.	A.	B.	Remarks.
Caustic Soda	NaO, HO	8	6·2	Injurious to the fabrics.
Carbonate of Soda	$NaOCO_2$, 10 HO	27	10	
Carbonate of Potash	$KO\ CO_2$, 2 HO	12·6	10	
Bicarbonate of Soda	$Na\ O\ 2\ CO_2, HO$	6	5·4	Not sufficiently efficacious; too volatile.
Borax	$Na\ O\ 2\ BO_3$, 10 HO	25	13·2	Destroys the fabrics above 212° Fahr.
Silicate of Soda	2 $Na\ O\ 3\ SiO_3$		15·5	Injures the appearance of the fabrics.
Phosphate of Soda	2 $NaOHO\ PO_5$, 24 HO	80	32	Not sufficiently efficacious.
Sulphate of Soda	$NaOSO_3$, 10 HO			A concentrated 72 p. c. solution is insufficient.
Bisulphate of Soda	$NaO\ 2\ SO_3, HO$	20	18·5	Destroy the fabrics.
Sulphite of Soda	$Na\ OSO_2$, 10 HO	25	10·3	
Tungstate of Soda	$NaOWO_3$, 2 HO	20	16	*Recommended on account of its being the only salt not interfering with the ironing of the fabrics.*
Stannate of Soda	$NaOSnO_2$, 3 HO	20	15·9	Injurious.
Chloride of Sodium	$Na\ Cl.$			Concentrated solutions are insufficient.
Chloride of Potassium	$K\ Cl.$			
Cyanide of Potassium	$K\ Cy$		10	Poisonous.
Sesquicarbonate of Ammonia	2 $NH_4\ O\ 3\ CO_2$, 3 HO			Not available.
Oxalate of Ammonia	2 $NH_4\ OC_4O_6$, 2 HO			
Biborate of Ammonia	NH_4O, 2 BO_3, 4 HO	5	3·6	Destroys the fabrics above 212°,
Phosphate of Ammonia	2 $NH_4O\ HO\ PO_5$		10	Efficient, but expensive.
Phosph. of Ammonia and Soda	$NaO\ NH_4OHO\ PO_5$, 8 HO	15	9·8	Expensive, and scarcely sufficiently efficacious.
Sulphate of Ammonia	$NH_4O\ SO_3, HO$	7	6·2	*Very efficient, and recommended on account of its low price.*
Sulphite of Ammonia	$NH_4O\ SO_2, HO$	10	9	Deliquescent.
Chloride of Ammonium	$NH_4\ Cl.$		25	Not sufficiently efficacious.
Iodide of Ammonium	$NH_4\ I$		5	Too expensive.
Bromide of Ammonium	$NH_4\ Br.$		5	
Urea	$C_2\ H_4\ N_2\ O_2$		40	
Thouret's Mixture	$\left\{ \begin{matrix} 3\ (NH_4\ Cl.) \\ 2\ (NH_4\ OHO,\ PO_5) \end{matrix} \right\}$		12	Efficient, but expensive.
Chloride of Barium	$Ba\ Cl.$		50	Not sufficiently efficacious.
Chloride of Calcium	$Ca\ Cl$, 6 HO	19·7	10	Deliquescent.
Sulphate of Magnesia	$MgOSO_3$, 7 HO	50	24·3	Not sufficiently efficacious.
Sulphate of Alumina	$Al_2O_3\ 3\ SO_3$, 18 HO	15	7·7	Destroys the fabric.
Potash—Alum	$KOSO_3\ Al_2O_3\ 3\ SO_3$, 24 HO	33	18	Not efficacious enough, and destroys the fabric.
Ammonia—Alum	$NH_4OSO_3\ Al_2\ O_3\ 3\ SO_3$, 24 HO	25	13	
Sulphate of Iron	$FeOSO_3$, 7 HO	53	28·8	Not sufficiently efficacious.
Sulphate of Copper	$CuOSO_3$, 7 HO	18	10	Poisonous.
Sulphate of Zinc	$Zn\ OSO_3$, 7 HO	20	11·2	
Chloride of Zinc	$Zn\ Cl, HO$	8	5·8	Deliquescent.
Protochloride of Tin	$Sn\ Cl, HO$	5	4·6	Deliquescent.
Protochloride of Tin and Ammonium	$Sn\ Cl\ NH_4Cl\ HO$	5	4·7	Becomes yellow, when exposed to the air.
Pinksalt	$Sn\ Cl_2\ NH_4\ Cl.$		7	Injures the fabric.

TABLE

Showing the increase in weight of Muslin prepared with various anti-flammable expedients.

Muslin (not starched) prepared with a solution of	Increased in weight about
7 per cent. of Sulphate of Ammonia .	18 per cent.
10 per cent. of Tungstate of Soda .	27 per cent.
12 per cent. of Thouret's compound .	24 per cent.

In the manufacturing process the weight increases at a somewhat higher rate: a piece of starched Tarlatan, weighing about 8½ oz., took up about 2 oz. of Sulphate of Ammonia from a 10 per cent. solution.

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Bury Court, St. Mary Axe,
London, E. C.
October, 1859.

Communications regarding the introduction of the Salts above recommended may be directed to

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MR. FRED. VERSMANN'S LABORATORY *is open every day from 9 o'clock* A.M., *till 6 o'clock* P.M., *for mercantile and agricultural analyses, and for researches in Chemistry as applied to arts and manufactures.*